Low Cost Countermeasure at Accident Blackspots : Malaysian Experience

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ABSTRACT

Every year, there are about 6,000 deaths caused by road accidents reported in Malaysia. As an effort to reduce road accidents, the government has implemented a number of road safety and accident countermeasures. In general, accident countermeasure implementation is divided into two major categories; i.e. high cost accident countermeasure which is a long term countermeasure and the other one is low cost countermeasure which is a short term countermeasure. This paper will discuss the implementation of low cost countermeasure at accident blackspots in Malaysia. By implementing low cost countermeasure at accident blackspots, many accident blackspots will be treated within limited financial allocation provided. In Malaysia, a total 755 accident blackspots were treated with low cost countermeasure within a 4 years period since 2004. This paper will focus on the aspect of planning, treatment methods, construction, monitoring of the effectiveness and improvement opportunities in the implementation of low cost countermeasures in accident blackspots based on Malaysian perspective.

1. INTRODUCTION

Road safety issues had been a major topic to be discussed among road administrators especially related to the development of road industry. The road network in Malaysia is divided into several different categories and they are managed by many road administrators. The road network comprises approximately 1,200km of expressways, 17,000km of Federal Routes and the remaining 65,000 km are State and Municipal roads. The different categories of roads are categorized based on the source of funding received for the management and maintenance of the road network. With thousands of kilometer of roads, the numbers of vehicles has significantly increased, approximately by 10% each year. This has also contributed to the increase of road accident numbers.

Safety on these roads has been an issue based on the number of deaths annually. The number of fatalities due to road accidents recorded in Malaysia is approximately 6,000 annually. The fatality index per 10,000 registered vehicles and per 100,000 populations are 3.7 and 23.0 respectively. In most developed countries, the fatality index per 10,000 registered vehicles is approximately 2.0 and fatalities per 100,000 populations ranging from 12.0 to 15.0. It has become Malaysian dream as a developing country to achieve a lower number in accident statistics. Thus, numbers of strategies and actions have been taken to improve this situation [1].

Among the strategies and actions taken are the need to look at means of improving the safety aspects of road at all stages from design, construction and the operations of the road network. The safety approach is generally pro-active and reactive. The pro-active approach is towards accident prevention through Road Safety Audit (RSA) and safer planning and design of roads. The reactive approach aims to result in reduction of accidents through accident scene (blackspot) investigation (ASI). This approach is applicable to the safety management for different categories of road, either the Federal roads or the State roads which are managed by Public Works Department Malaysia (PWD Malaysia).

2. ROAD SAFETY STRATEGIES AND IMPLEMENTATIONS IN MALAYSIA

There are four basic strategies for accident reduction through the use of countermeasures implemented in Malaysia namely single site, mass action scheme, route action plan and area-wide scheme [2]. The implementation of road safety programs are dependent on the availability of data which contains full information about accidents and their locations so that common features which have contributed to the accidents can be identified. However, the implementation is highly dependent on availability of fund. The four basic strategies are cited further as below:

a) Single site/Blackspot – The treatment of specific types of accident at a single location, such as at a junction, but could be in areas of 200-400 m in diameter or 300-500 m stretches of road;
b) Mass action scheme – The application of remedy to locations with a common accident problem, i.e. skidding on wet road surface, head-on collision, excessive speed approaching roundabout etc.;
c) Route action plan – The application of remedies along a route with a high accident rate; and
d) Area-wide scheme – The application of various treatments over a wide area of town, i.e. traffic management and traffic calming in areas bounded by links on a network, housing areas or 1 km squares having higher accidents than a preset level.

Through the Malaysia 5-Years Plan and other infrastructure development program, efforts to increase the level of road safety have been implemented for the first time since the 6th Malaysia Plan (1991-1995). Funds related to road safety issues have been allocated by World Bank in the early stage. However, the funds now have been allocated through a development program budget. In average, funds allocated for road safety programs are between 2% to 8% of the total infrastructure development program budget received by PWD Malaysia. **Table 1** shows the summary of total funds allocated for road safety implementation each 5-years Malaysia Plan (MP) and **Table 2** shows the funds allocated for road safety implementation compared to infrastructure development funds.

Table 1. Summary of total funds allocated for road safety implementation each Malaysia Plan (MP).

Malaysia Plan (MP)	Project/Program	Total Allocation (RM 'million)
6th MP (1991-1995)	a. World Bank – Road Safety Improvement	15.60 (USD 4.36 million)
	b. Construction of Overtaking Lanes	10.00 (USD 2.79 million)
7th MP (1996-2000)	a. World Bank – Road Safety Improvement	20.40 (USD 5.70 million)
	b. Construction of Overtaking Lanes	8.40 (USD 2.35 million)
	c. Improvement of 147 Hazardous Locations Along Federal Roads	52.88 (USD 14.77 million)
	d. Maintenance Road Safety Program	47.43 (USD 13.25 million)
8th MP (2001-2005)	a. Improvement of Hazardous Locations	60.00 (USD 16.76 million)
	b. Road Safety Program	38.00 (USD 10.61 million)
	c. Construction of Motocycle Lane on Federal Roads	126.10 (USD 35.22 million)
	d. Maintenance Road Safety Program	167.77 (USD 46.86 million)
9th MP (2006-2010)	a. Improvement of Hazardous Locations	55.00 (USD 15.36 million)
	b. Road Safety Program	51.27 (USD 14.32 million)
	c. Construction of Motocycle Lane on Federal Roads	18.50 (USD 5.17 million)
	d. Maintenance Road Safety Program	166.82 (USD 46.60 million)

Table 2. Road safety implementation funds compared to infrastructure development funds each Malaysia Plan.

Malaysia Plan (MP)	Road Safety Fund (RM 'million)	Infrastructure Development Fund (RM 'million)	Percentage (%)
6th MP	25.60 (USD 7.15 million)	1,611.64 (USD 450.18 million)	1.59
7th MP	129.11 (USD 36.07 million)	1,916.50 (USD 535.34 million)	6.74
8th MP	391.87 (USD 109.46 million)	3,037.17 (USD 848.37 million)	12.90
9th MP	291.59 (USD 81.45 million)	11,158.00 (USD 3.12 million)	2.61

With limited funds provided by the government, strategic research and planning is vital in the implementation of road safety program. Thus, most of the funds are allocated for the high-cost/long-term road safety programs such as construction of motorcycle lanes, construction of overtaking lanes, road straightening etc. Implementation of these programs requires proper research, planning and total data management analyzed for a certain period to cite the localized accident pattern. This accident pattern will help road designers to clearly understand factors that contribute to road accidents and prepare the design to improve hazardous locations.

The implementation of high-cost program from the planning stage right up to the completion stage will take normally about 2 to 5 years. Thus, if all road safety issues have to be funded by infrastructure development funds alone, there will not be enough funds to treat all road safety cases, thus leading to a delay in implementation of treatment programs. There will also be a shortage of funds to treat the emergency repairs. In order to tackle the road safety deficiencies that cropped up from time to time, PWD Malaysia has set the target to eliminate the accident blackspots. Therefore, in 2004, PWD Malaysia has launched the first low cost countermeasure at accident blackspot program. The implementation of this program is funded via yearly road maintenance allocation.

3. LOW COST COUNTERMEASURE

Low cost countermeasure at accident blackspots is defined as simple low cost measures which can significantly improve road safety problems at hazardous sites. This countermeasure is set to tackle road safety matters related to engineering, enforcement, education as well as encouragement. The implementation of well planned low cost countermeasure programs had been started in 2004 when PWD Malaysia realized that the accident statistics has deteriorated. Since then, PWD Malaysia has set the target to eliminate as many accident blackspots as possible, and a yearly allocation fund of RM6.0 million was allocated to implement this program.

Low cost countermeasure at accident blackspot programs mainly focused on accident blackspot elimination by the engineering approaches. Accident blackspot is defined as a section of road which the occurrence of accident tends to be less random [3]. It is likely that some aspect of highway design, layout, and state of road or traffic control is a contributory factor in most accident occurrences. It is well established that considerable safety benefits may result from the application of appropriate road engineering or traffic management measures at hazardous locations.

Table 3 shows a simple list of low cost countermeasures for general, urban and rural situations which have been found effective [3]. Each accident site will have its own set of contributory factors which define the problem to be overcome by these possible remedies. However, it should be stressed that safety at the site under investigation should not be the only consideration when choosing an appropriate countermeasure. The effect of that measure on the surrounding network should be predicted. Having identified dominant accident types at a blackspot area, this will help to give an indication of an appropriate remedial measure.

Table 3. Simple list of low cost countermeasures for general, urban and rural situations which have been found effective [3].

a. General Accident Situations

Accident type	Possible Remedy
Wet road:	
Skidding	Restore micro/marco texture with use of high psv aggregate in: a). surtace dressing b).bituminous surfacing or surface grooving
Spray reducing visibility	Restore macro texture Use of porous asphalt
Aquaplaning	Improve drainage/road camber
Darkness	Improve macrotexture
Poor delineation	Make texture of markings contrast well with road surface Improve road surface texture
Darkness:	
Poor surface luminance	Match surface texture with installation
Inadequate luminance	Renew surface Street lighting
Poor delineation	Lane/edge markings: reflectorised pavement markers, delineator posts
Loss of control/ drowsiness	Apply paint and reflectors to the fixed object Road markings to guide around obstruction Re-site obstacles Frangible columns (rural non footpath) Improve/install lighting Safety fences/guarg rail Crash cushions

b. Urban Accident Situations

Accident type	Possible Remedy
Junctions:	
Turning traffic	Channelisation Roundabout or traffic signals Mini-roundabout Install stop sign/other warning signs Eliminate view obstructions Improve macrotexture Provide protected right turn bay (and separate phase if signalized) Install lighting/illumination of sign Create one-way streets Prohibit right turns and route turning traffic via alternative route (with signs) Restrict U-turns Traffic signal cameras
Overshoot from minor road	Traffic islands
Pedestrian	Pedestrian stage in signals system Provide refuge islands Prohibit kerb parking Provide adequate street lighting
Non-junction:	
Pedestrian	Provide pedestrian footway Install pedestrian crossings Guardrails/pedestrian barriers Speed reducing humps (residential areas) Access restriction (residential areas) Traffic calming measures
Parked vehicles	Restrictions on parking Rerouting of traffic to special through street
Two-wheelers	Special motorcycle lanes
Excessive's speed	Enforcement Road humps Chicanes

c. Rural Accident Situations

Accident type	Possible Remedy
Junctions:	
Turning traffic	Channelisation Additional lanes (acceleration, deceleration) Traffic islands (real or ghost / hatching) Vegetation control Roundabout or traffic signals Yellow bar markings Rumble areas Prohibit right turns and route turning traffic via alternative route (with sign)
Overshoot from minor road	Traffic islands
Sight restriction	Removal of vegetation Relocation of minor access Realignment if ablique angled junction Adjustment of minor road profile
Non-junction	
Overtaking	Double white lane markings according to standards Restrictive signs Centre median/tactile dividing strip Construct new section of dual for overtaking
Bend loss of control	Super-elevation/realignment Advisory speed sign Improve skid resistance Install raised pavement markers/cat's eyes Guardrail / 4-wire barriers
Excessive speed	New speed limit / Enforcement Carriageway definition Rural by-pass

4. IMPLEMENTATION OF LOW COST COUNTERMEASURE PROGRAM

The implementation of low cost countermeasure programa in Malaysia involves ten steps that can be listed under five main steps namely, investigation, diagnosis, selection, implementation and evaluation [3]. **Figure 1** illustrates the flow chart of ten steps that involve in the implementation of low cost countermeasure program in Malaysia.

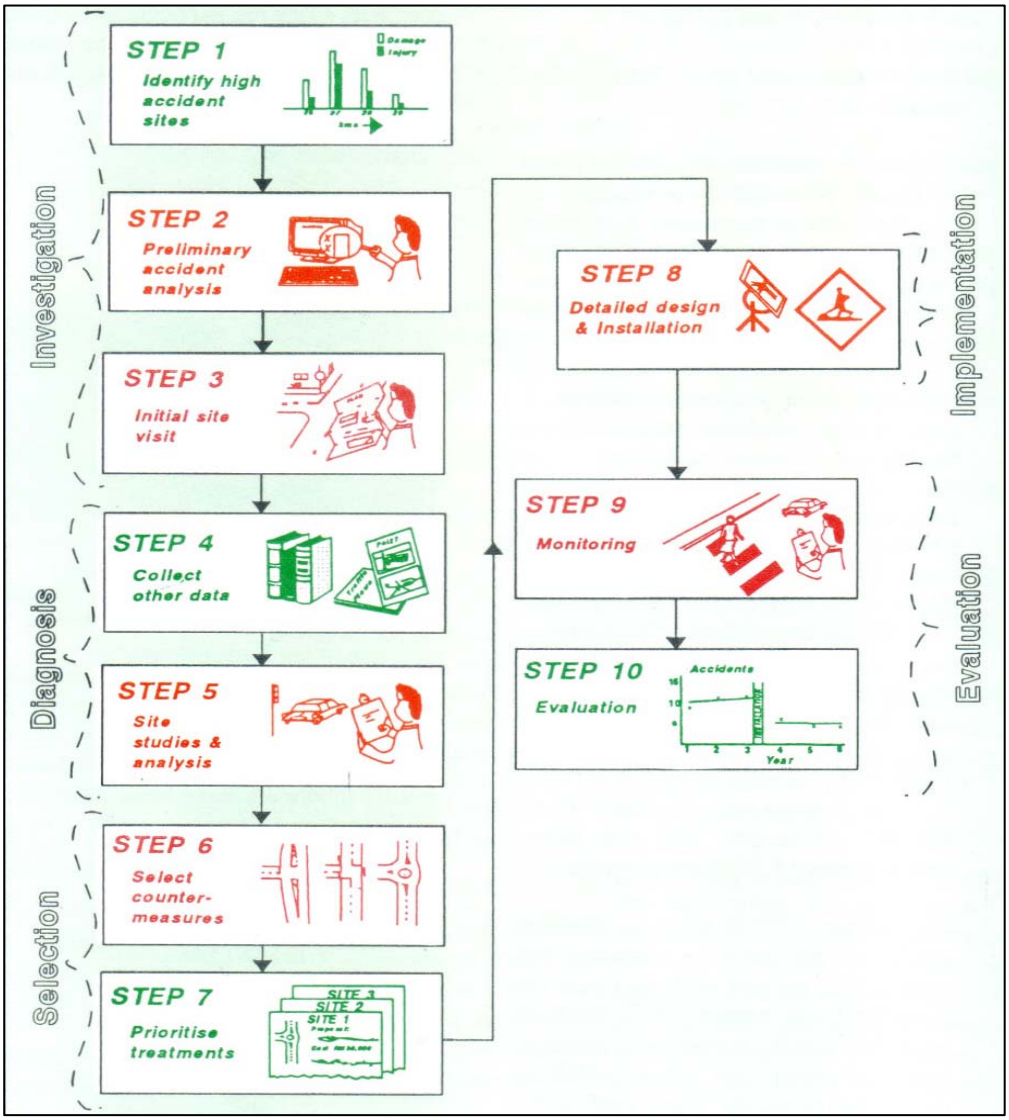

Figure 1. The flow chart of ten steps that involve in the implementation of low cost countermeasure program in Malaysia [3].

An essential element of any accident reduction and prevention strategy is the collection and investigation of road accident data. All accident data originates with the recording of details by the police either at the scene of an accident or as subsequently reported to them at the local police station by those involved. This data contains all records associated with the accident such as witness statements, photographs, description and sketch diagram of the scene as found by the police reporting officer.

Accidents at hazardous locations are relatively rare events having a considerable random element, particularly in the time at which they occur. Therefore, the first step is to study the data in a logical manner to identify and prioritize problem sites. In general, three years is a minimum period to produce a reliable ranking of hazardous sites and make evaluations of the treatment. Then, preliminary

accident analysis is being done to check that the site has higher numbers of accidents than might be expected.

Initial site visit is a very important element to become familiar with the site and to ensure that available plans are up to date and they are detailed enough to identify specific features which may be contributory to accidents. It may be possible to attempt to further rank sites at this stage into whether they will be easy or hard to treat. Easy sites are those where effective remedial measures can be readily identified and low cost. Hard sites are those which do not provide clear indication of appropriate treatment or where this is likely to be very costly. The easy sites should be tackled first as they provide good return of benefits.

In practice, an accident can be assigned by many underlying factors which mean that a single collision type can be classified according to many factors or accident types. Unfortunately, many of these underlying factors would not appear in the accident report. Therefore, it is essential to collect further data to re-classify the accidents and produce a dominant collision type in which there is at least one common factor which could be treated.

It is possible that obvious difficult features of the site may have been observed at the initial site visit. However, new accident data and feature can be obtained from site studies with more detailed knowledge of the collision types and making the same maneuver while driving to simulate the incident.

In selecting countermeasures, it should be checked that:

a) the measures are likely to decrease the type of accident at which it is aimed;
b) no further increase in other types of accident is likely to occur as a result of the selected measure; and
c) there are not likely to be any unacceptable effects on traffic movement or the environment.

Treatments and sites need to be prioritized before it is implemented. The standard approach for the ranking of treatments is to carry out a cost-benefit analysis based on estimated benefits of the scheme and simply place these in priority order on the basis of the best return. However, other contributing factors may be analyzed such as the effectiveness of countermeasure, treatment cost, availability of funds, and difficulties of treatment.

After appropriate countermeasure has been selected, detailed design should be prepared for construction and implementation. Ideally, a road safety audit needs to be carried out on selected countermeasure at the design stage and immediately after the construction to ensure that all road schemes operate as safely as possible.

The treated site should be monitored immediately after completion of the construction and regular visits made in following days, weeks or months until the team is satisfied that the scheme is operating in the expected way. Then, evaluation of whether the treatment has successfully achieved its objective of reducing the number of accidents.

5. EFFECTIVENESS OF LOW COST COUNTERMEASURE PROGRAM

The effectiveness of the implementation of this program has to be monitored and evaluated for two years. As stated earlier. up to year 2007, 755 accident blackspots has been treated with total cost of RM26.1 million (USD 7.29 million). All these accident blackspots are selected based on the PWD Malaysia accident database reported by District Engineers, news and police. From the database, only accident blackspots which recorded fatal accidents will be considered in the program. **Table 4** shows the total allocation and number of accident blackspots that have been treated in low cost countermeasure program from 2004 to 2007 and type of accidents reoccurred.

Table 4. Total allocation and number of accident blackspots that have been treated in low cost countermeasure program from 2004 to 2007 and type of accidents reoccurred.

Year	No. of Locations	Total Cost (RM 'million)	Fatal Accident	Severe / Slight / Damage Accident	No Accident
2004	132	5.2 (USD 1.45 million)	4	24	104
2005	255	7.8 (USD 2.18 million)	3	16	236
2006	217	5.7 (USD 1.60 million)	2	0	215
2007	151	7.4 (USD 2.07 million)	0	4	147
Total	**755**	**26.1 (USD 7.29 million)**	**9**	**44**	**702**

For the purpose of evaluation, every accident blackspot that has been treated will be monitored each month since the completion of proposed countermeasure. The treated blackspot will be monitored each month weather there is any accident reoccurring within the effective countermeasure range. Any reoccurring accident will be recorded to further evaluate the accident type, pattern and other important features that may not have been taken into consideration when the proposed countermeasure detailed design was prepared. In general, reoccurring accident can be divided into four categories namely as below:

a) same location and accident type;
b) same location and different accident type;
c) same accident type and different location;
d) different in number of injury, fatality and damages cost.

However, reoccurring accident at treated locations is recorded by the number of locations involved. As a comparison, accident types such as fatal, severe or slight injury and damages only is also recorded to compare the effectiveness whether the countermeasure has been successful to help reduce number of accidents or fatalities.

From **Table 4**, 78% locations out of 132 locations that have been treated in 2004 have no reoccurring accident. 3% of treated accident blackspots which is 4 locations has recorded fatal accident while 24 locations recorded other type of accident. It means, 96.97% of locations not recording any fatal accident during the monitoring term for 2 years.

For the locations that have been implemented in year 2005 program, 98.69% or 251 out of 255 locations not recording any fatal accident. Only 3 (1.2%) locations have recorded fatal accident while 16 (6.3%) recorded other type of accidents.

For the year 2006 program, 99.54% or 215 out of 217 locations not recording any fatal accident. Only 2 (0.9%) locations have recorded fatal accident while no other type of accidents recorded during the 2 years monitoring term. For the 2007 program, only 151 locations were treated. From these 151 locations, no location has recorded any fatal accident which means 100% of treated locations were not recording any fatal accident during the monitoring period. There are 4 locations which have recorded severe/slight/damage accident during the monitoring term which is 2.6% out of total treated locations.

As conclusion, 98.81% of treated locations have achieved the objective of this program to eliminate accident blackspots and make the accident become more rare and random while the contributing factors are not because of road engineering deficiencies. **Chart 1** shows the percentage of fatal accident and other type of accidents that happened at low cost treated locations.

Based on further investigation at reoccurred locations, accident is reoccurring because the countermeasures implemented were not adequate and have not tackled the root cause of accident. Thus, all these locations need further treatment. If there is still a fatal accident recorded, planning to opt to a high cost countermeasure at the particular stretch should be considered.

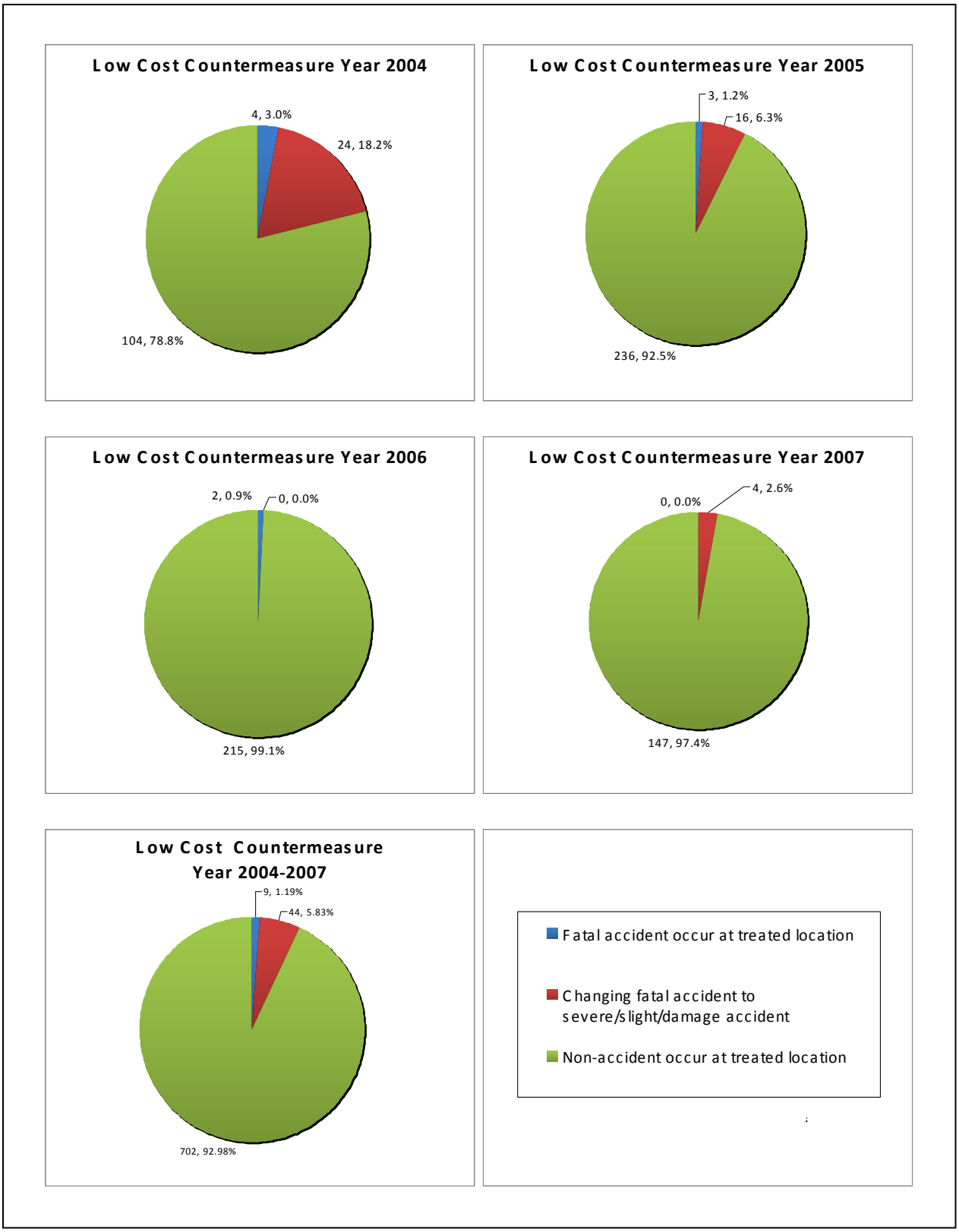

Chart 1. Percentage of fatal accident and other type of accidents that happened at low cost treated locations.

6. CHALLENGES AND IMPROVEMENT

In early 2008, a pilot study on the International Road Assessment Program (iRAP) has been introduced with the aim of providing safer road environment [4]. The program surveyed and evaluated 3,500 kilometers of major Federal Roads in Peninsular Malaysia in terms of safety risks to various road users and recommends countermeasures towards providing a forgiving road environment. Road geometry and roadside condition are the main parameters in the evaluation. The outcome of the evaluation is the number of stars which indicate the level of safety of the road environment; 1-star indicates the requirement of safety treatment at particular stretch while 5-star indicates the safest stretch of road.

Figure 2. Star Mapping of car occupants obtained from iRAP assessment program for selected Federal Road in Malaysia [4].

Based on the pilot study, some portion of the surveyed network obtained between 1 to 3-star only. **Figure 2** shows the iRAP Star Rating mapping for car occupants while **Table 4** shows the summary of iRAP Star Rating mapping for selected Federal Roads in Malaysia [4]. As a recommendation towards improvement of road safety in Malaysia, iRAP has identified the requirement of RM550 million (USD 153.63 million) worth of initial road safety program to be implemented over five years. If the required fund is approved, there will be big changes in accident statistics based on the effectiveness of the program.

Table 4. iRAP Star Rating mapping for selected Federal Roads in Malaysia [4].

	Car Occupants		Motorcyclists		Bicyclists[1]		Pedestrians[1]	
Star Rating	Length (km)	%	Length (km)	%	Length (km)	%	Length (km)	%
☆☆☆☆☆	0 km	0%	0 km	0%	0 km	0%	0 km	0%
★★★★	239 km	9%	186 km	7%	9 km	2%	0 km	0%
★★★	822 km	31%	905 km	35%	63 km	16%	476 km	48%
★★	1,127 km	43%	1,270 km	48%	261 km	65%	508 km	51%
★	433 km	17%	260 km	10%	66 km	16%	8 km	1%
	2,621 km	100%	2,621 km	100%	398 km	100%	992 km	100%
Not Rated					2223 km		1,629 km	

[1] Note: Percentage values reflect the proportion of the network where bicycle or pedestrian demand exists. Where bicycle or pedestrian demand is zero the section has not been rated.

Limitation of fund for road safety implementation program is the biggest challenge in Malaysia. As a result, some road designers and consultants will choose to compromise on road safety rather than other scope of works. Considering up to 5% increase in road length each year with the development of new roads, there will be many more accident blackspots created injudiciously. Therefore, it is another big challenge to increase public concern on road safety especially to the relevant highway planning unit, economic planning unit, road designing unit, road business unit and stakeholders which will oversee the implementation of new road projects start from the planning stage. Road safety should not be compromised in any stage of road development.

Apart from that, PWD Malaysia is keen to expand the study for the whole network in Malaysia which will cover all Federal and State Roads. This exercise is expected to be completed within two years and will cost approximately RM25 million (USD 6.70 million). The outcome of the study will be the future perspective and recommendation to implement low cost countermeasure throughout the country. Therefore, road safety improvement program will never end even if there is no more accident blackspot.

7. CONCLUSION

With an ever-growing road infrastructure network to manage and the rising expectations of the road users to contend with, the challenges facing PWD Malaysia are becoming more complex. The need to put road safety as the highest priority in road development with environmental preservation and higher cost benefit calls for prudence and objective-oriented in approving development plans. The art of convincing the stakeholders on the importance of adequate road safety funds to reduce the bigger portion of accident lost, must be acquired through staff training and proper use of comprehensive and effective road safety management system. Incorporation of quality management and procedures at the planning, design, construction and maintenance of road network ensures road safety level of the road users. Above all, provision of safer roads for the public needs solicit preemptive actions in anticipation of the future road transportation scenarios. Lastly, PWD Malaysia hopes to become one of the prime enabler towards safer roads in Malaysia's Zero Fatality Vision.

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